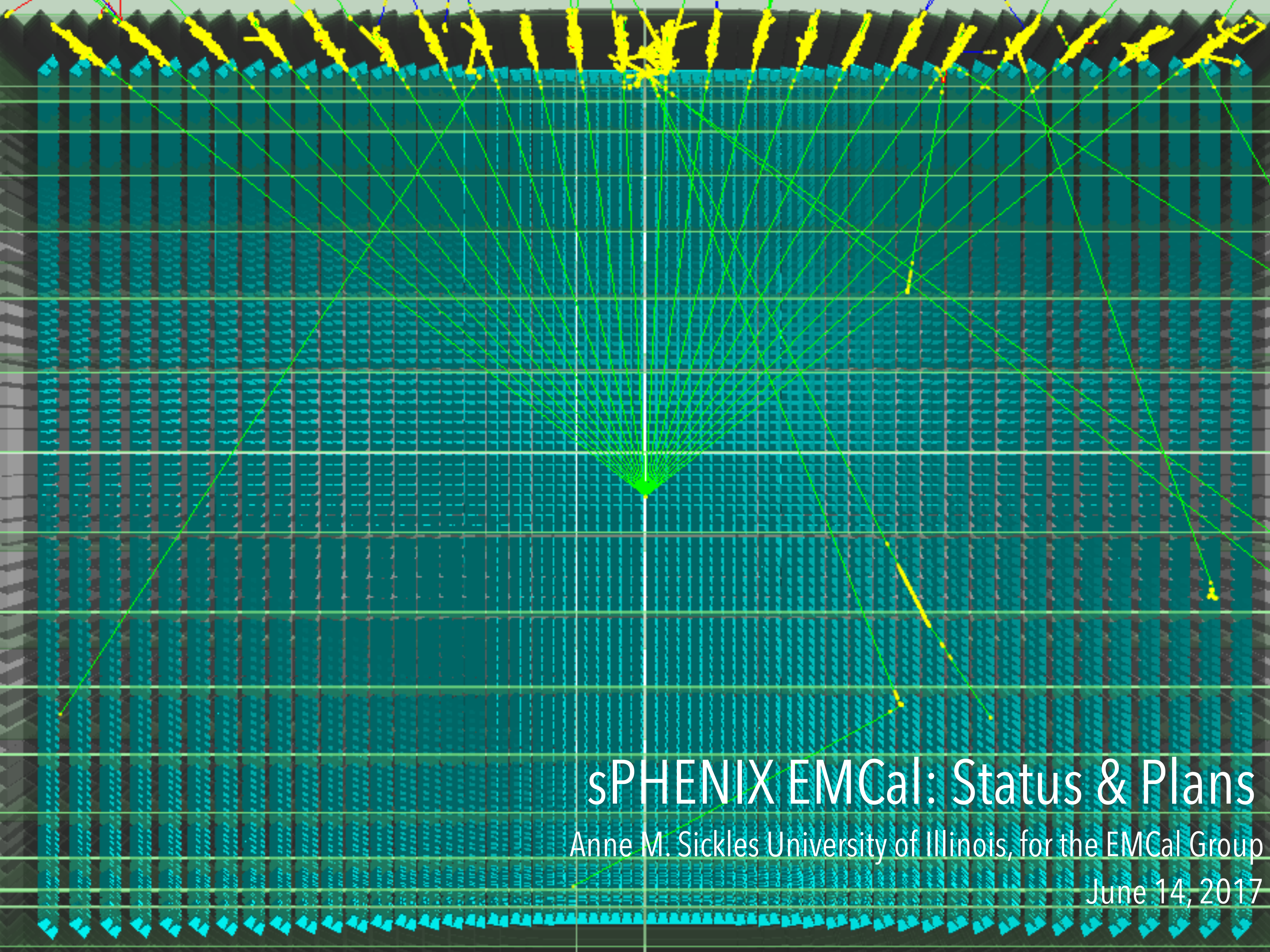


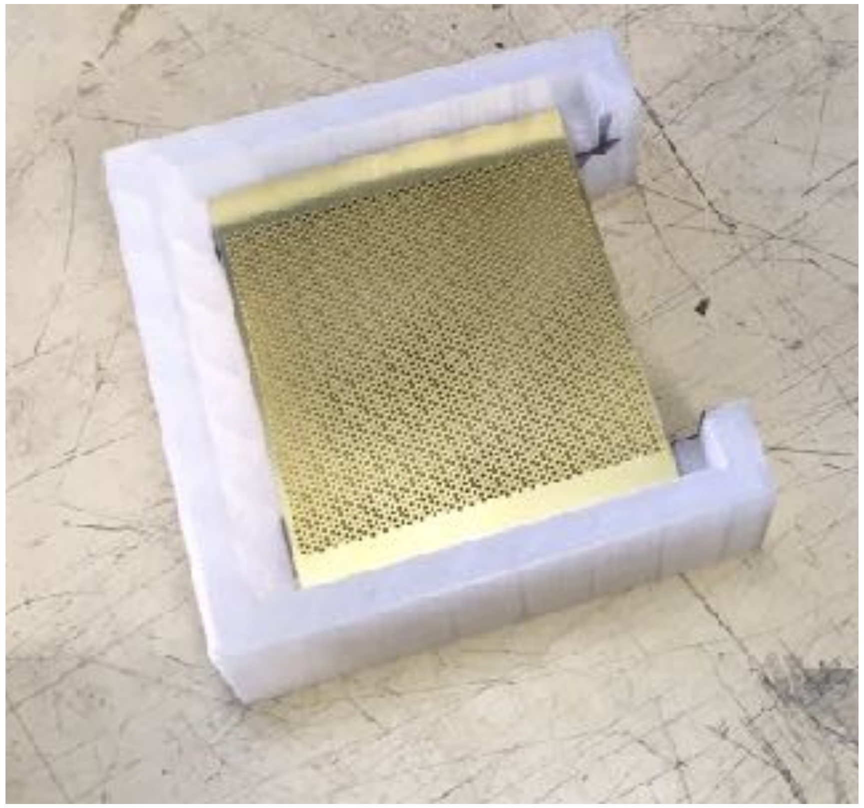
sPHENIX EMCal: Status & Plans

Anne M. Sickles University of Illinois, for the EMCal Group

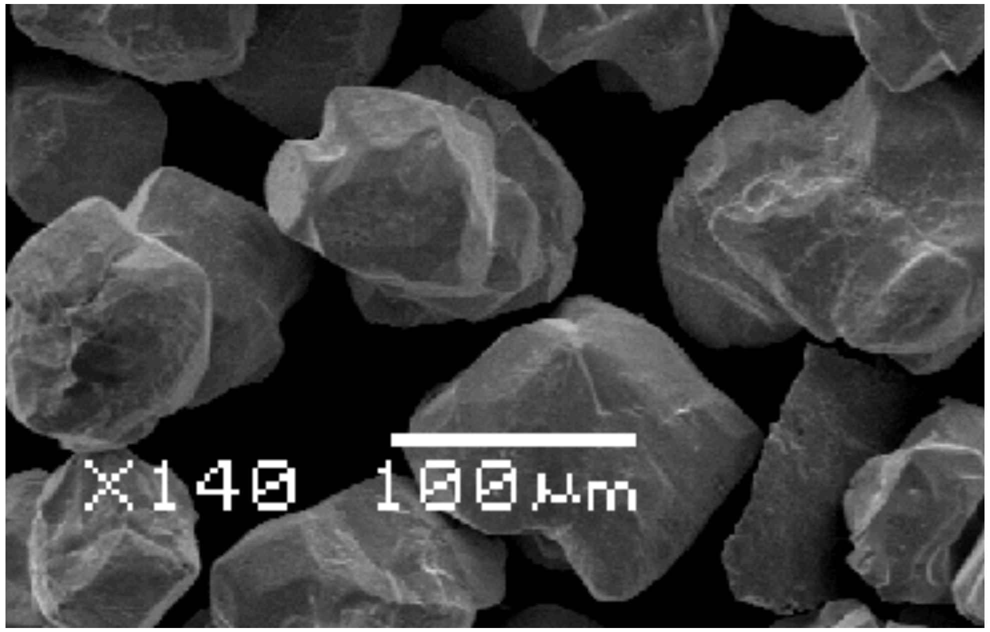
June 14, 2017

EMCal module componets

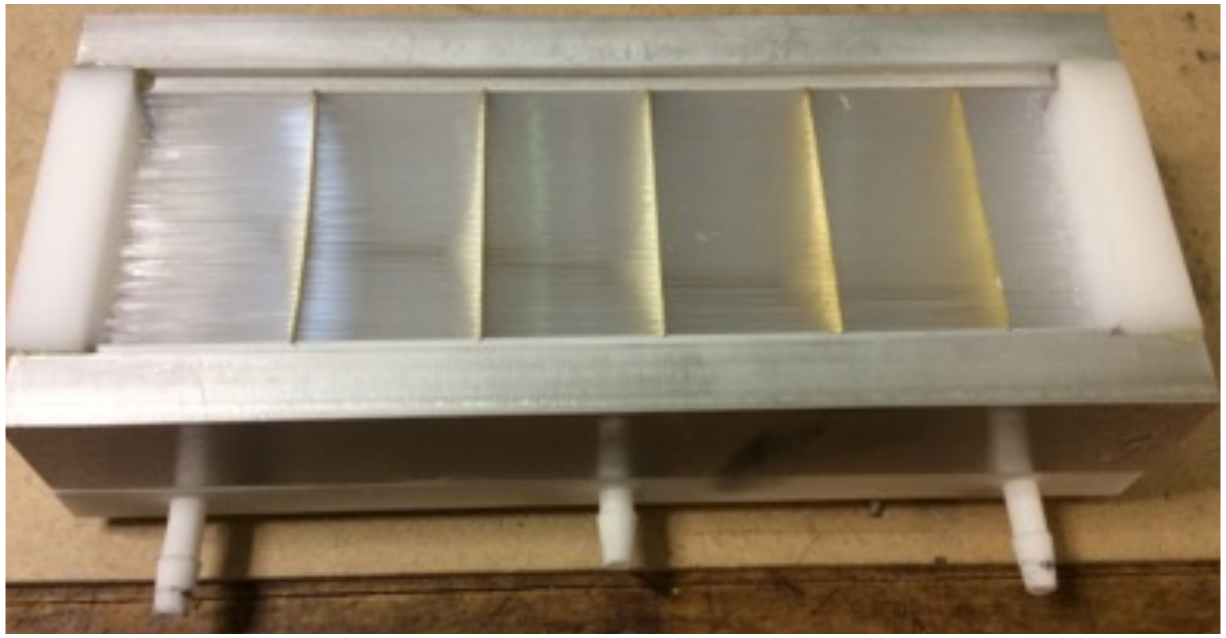
screens



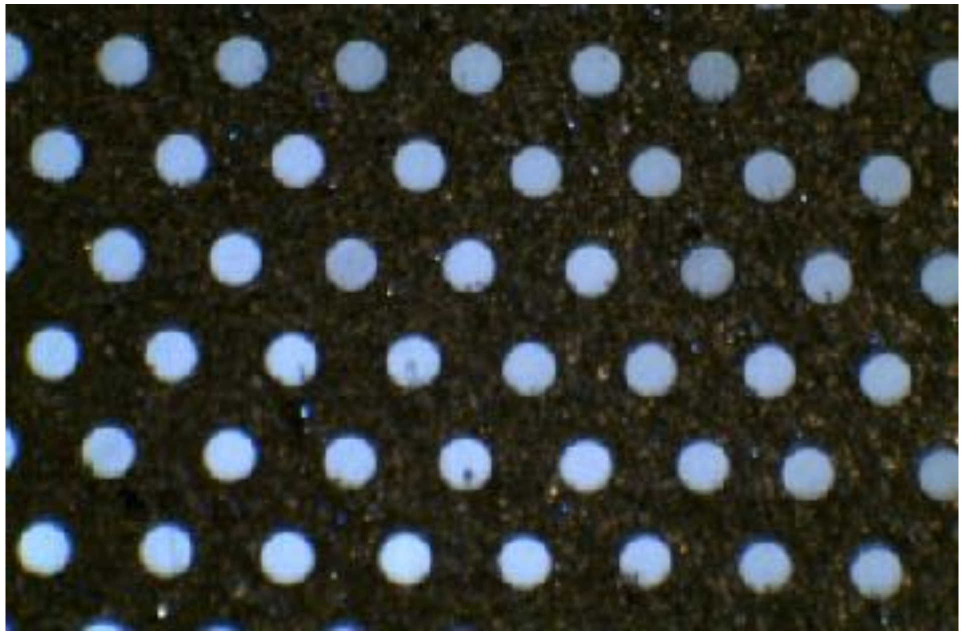
SEM of tungsten powder



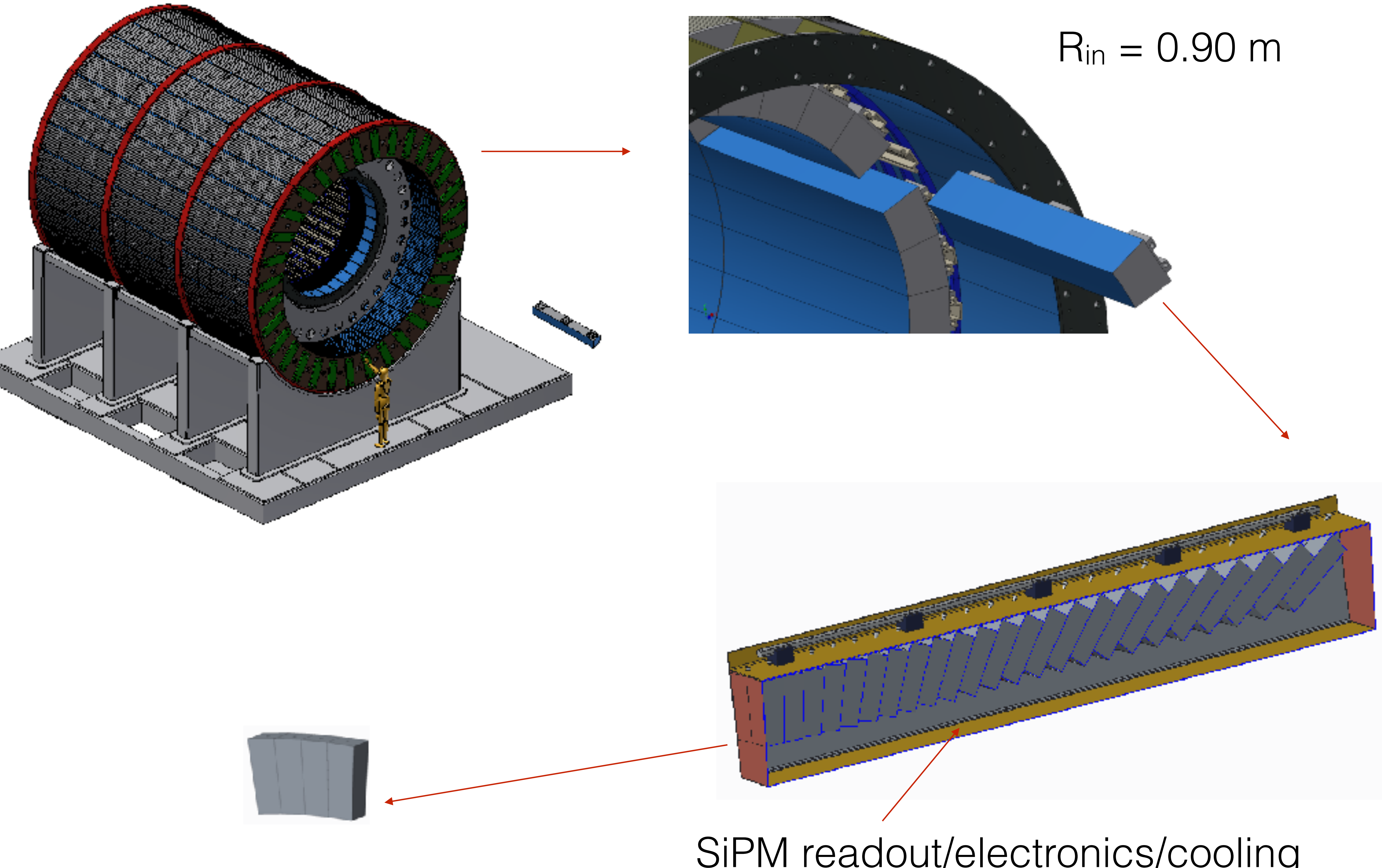
fiber assembly before filling



diamond fly cut end



EMCal structure



what are our specs?

from the CDR:

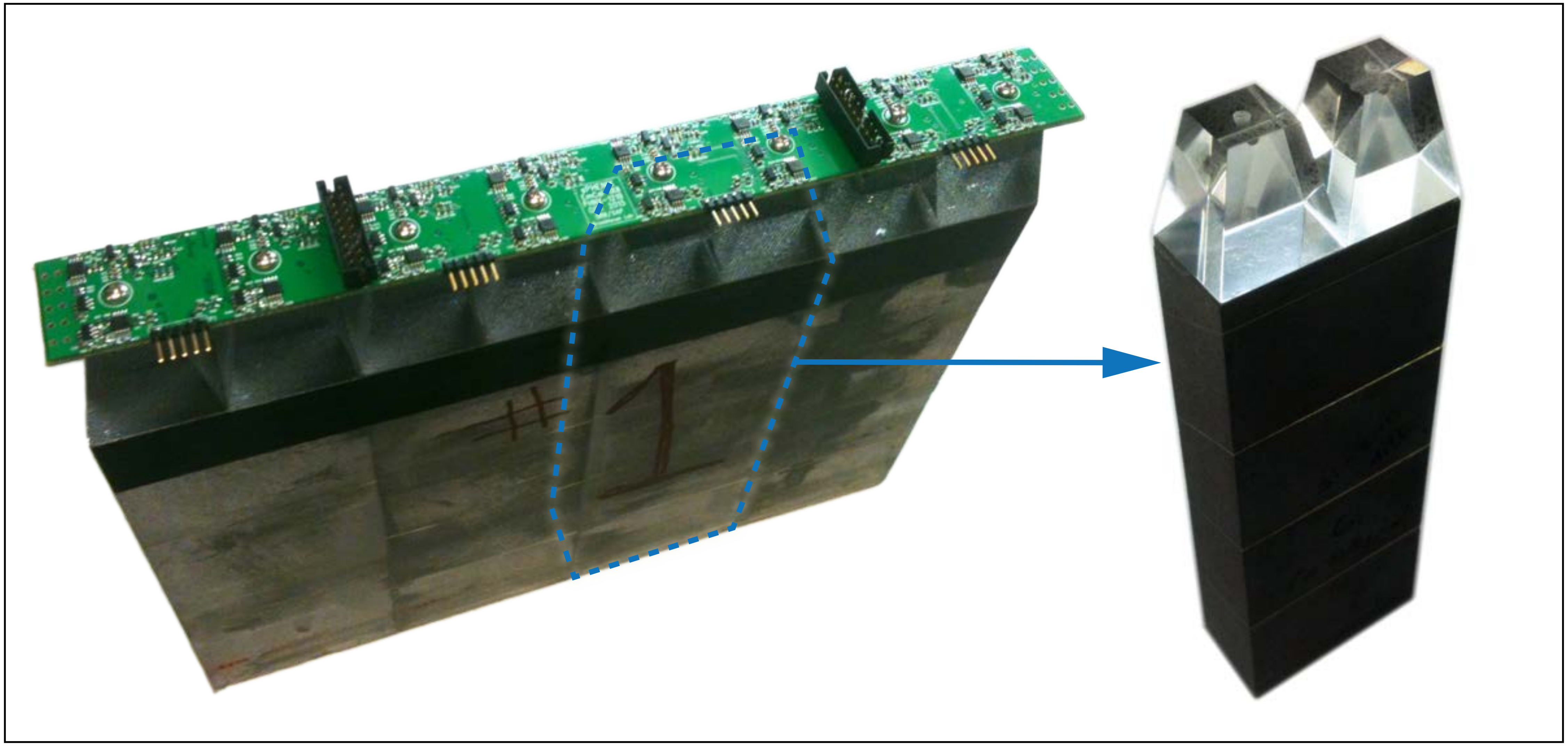
- Large solid angle coverage ($\pm$ 1.1 in η, 2π in ϕ)
- Moderate energy resolution ($\leq$ 15%/$\sqrt{E}$)
- Fit inside BaBar magnet
- Occupy minimal radial space (short X_0, small R_M)
- High segmentation for heavy ion collisions
- Minimal cracks and dead regions
- Projective (approximately)
- Readout works in a magnetic field
- Low cost

EMCal prototype cheat sheet

- 2016 prototype: 1D projective, analysis finished: 1704.01461, 64 towers/32 blocks
- 2017 prototype: 2D projective (first time ever) high η blocks, analysis well underway, 64 towers, 16 blocks
- 2018 prototype (v2.1): 2D projective high η blocks, building this summer, testing February/March 2018, 64 towers, 16 blocks
- pre-production prototype: 2D projective, full η coverage, 2π / 32 in Φ, no beam test, building fall/winter 2017-2018, 384 towers / 96 blocks

2016 prototype

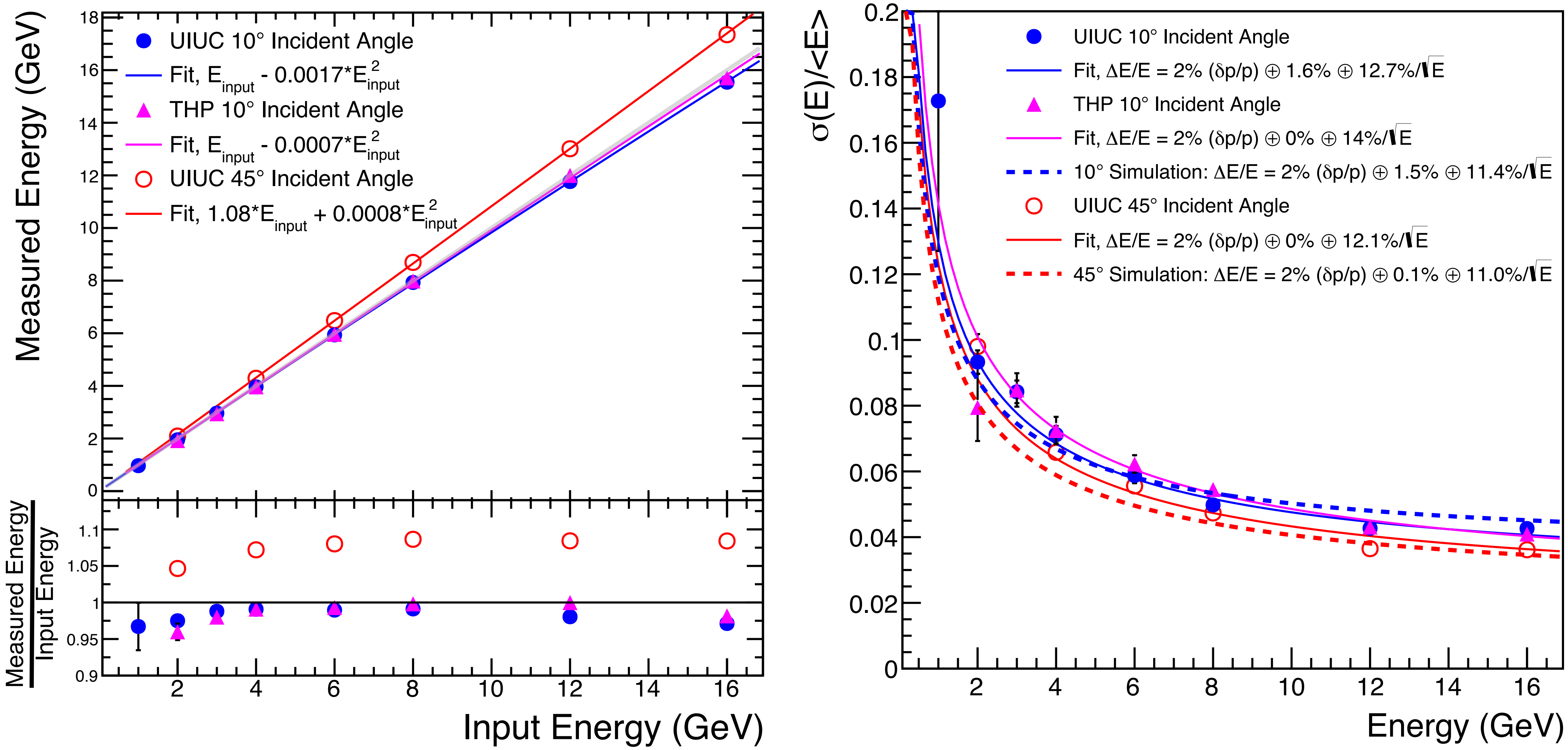
- 1D projective towers
- 2 towers / block
- trapezoidal lightguides with 4 SiPMs / tower



test beam paper:1704.01461

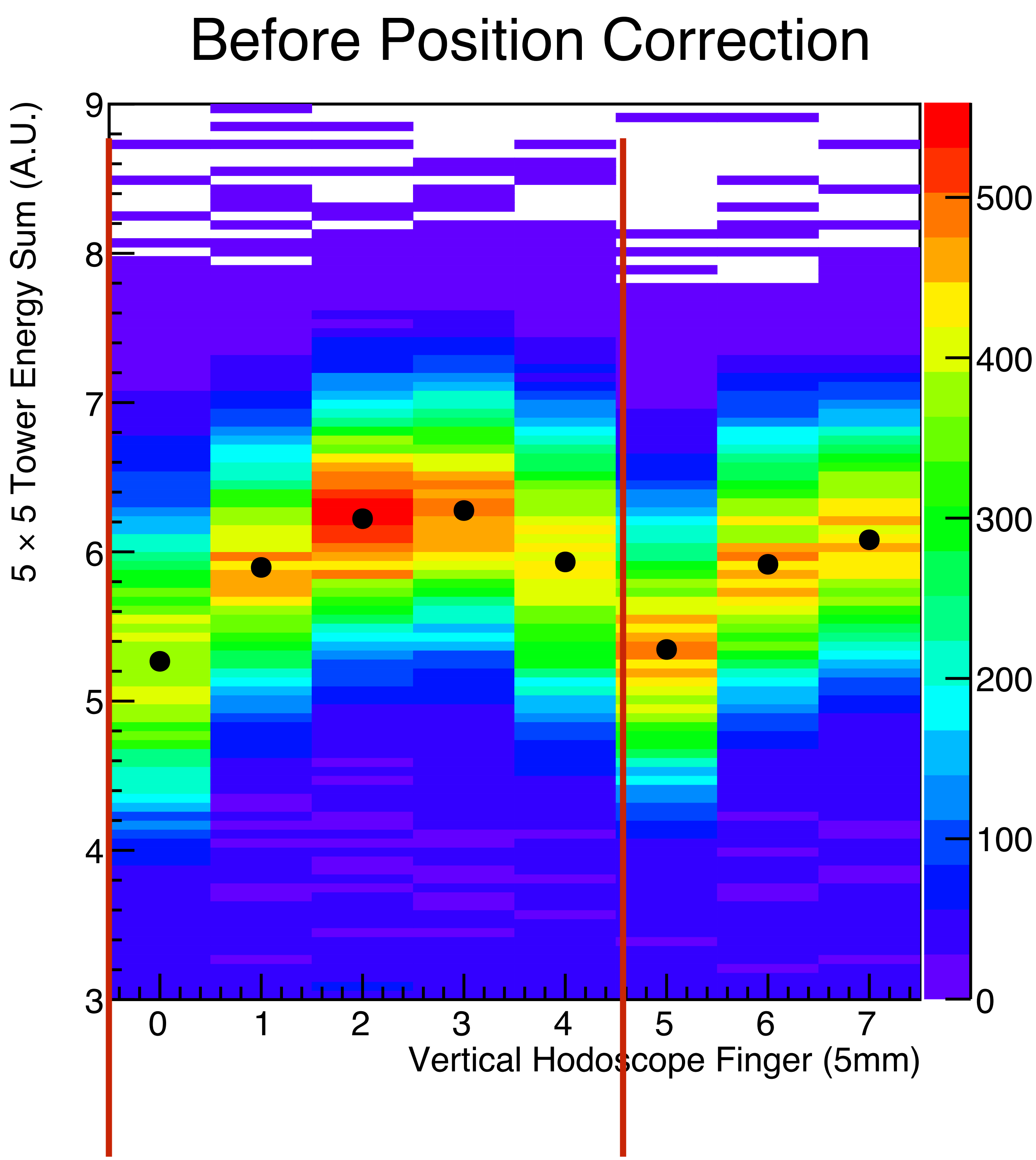
EMCal energy resolution & linearity

center of tower (selected via hodoscope)



- similar performance between **industry** at **Illinois** built blocks
    - resolution better than our requirements
- **larger tilt angles** → shallower showers
- deviations from linearity in part due to beam energy shifts from nominal values

position dependence of energy scale

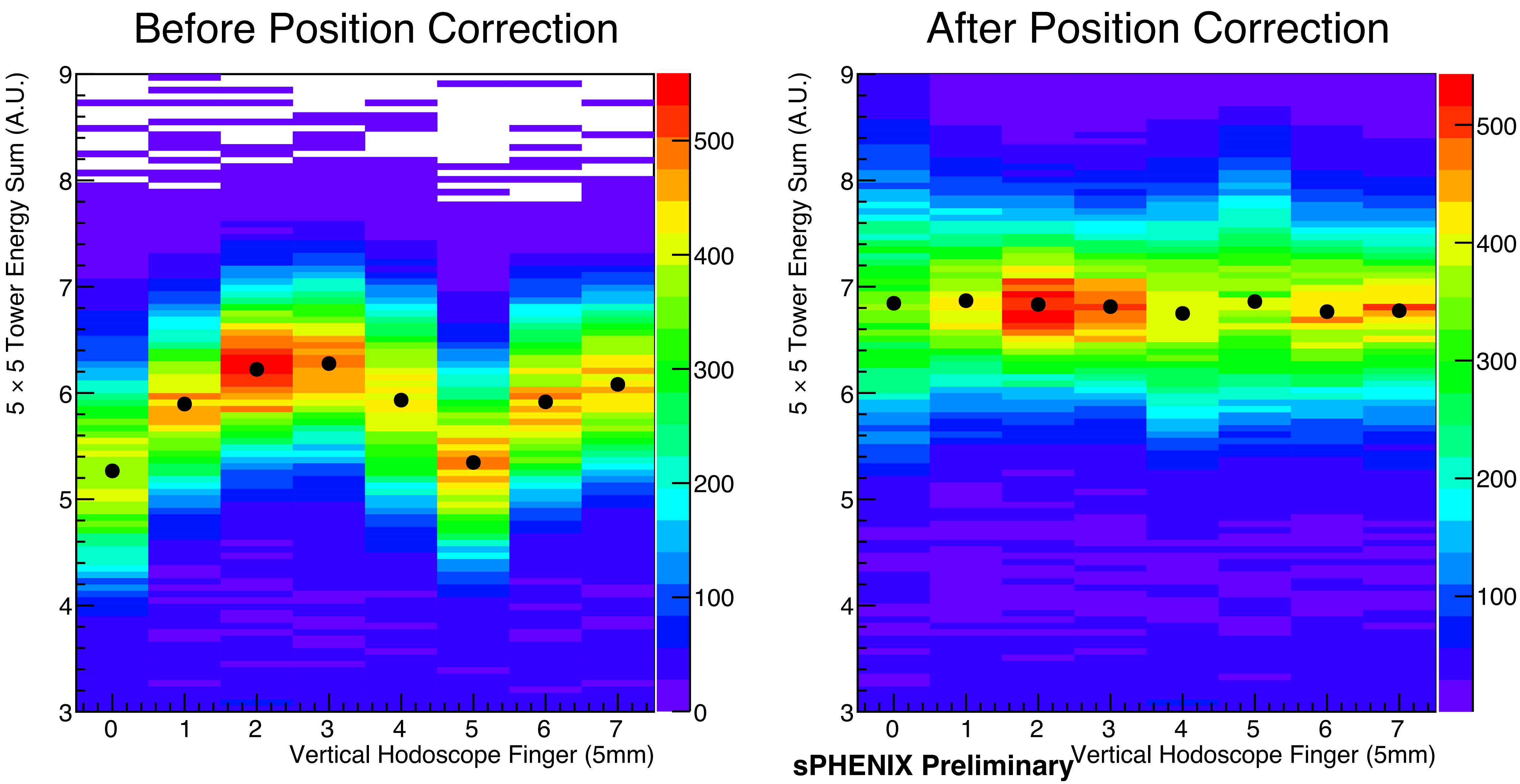


width of tower

- **sources**:
  - lightguide inefficiency near edges
  - gaps in fibers between towers?

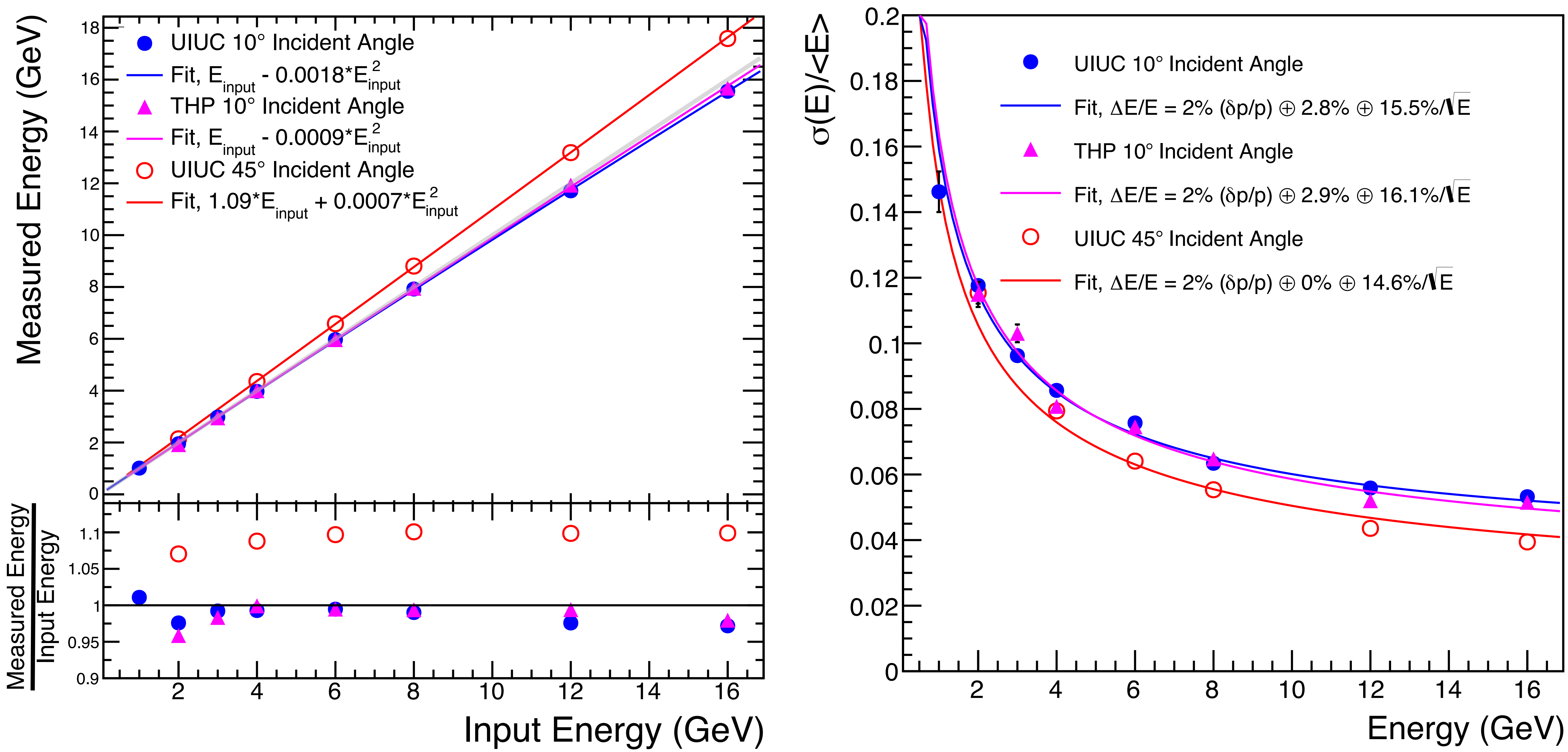
position dependence of energy scale

use 2D position correction based on the hodoscope



EMCal energy resolution & linearity

after application of position correction



energy resolution ~15% / √E after correction for **Illinois blocks**

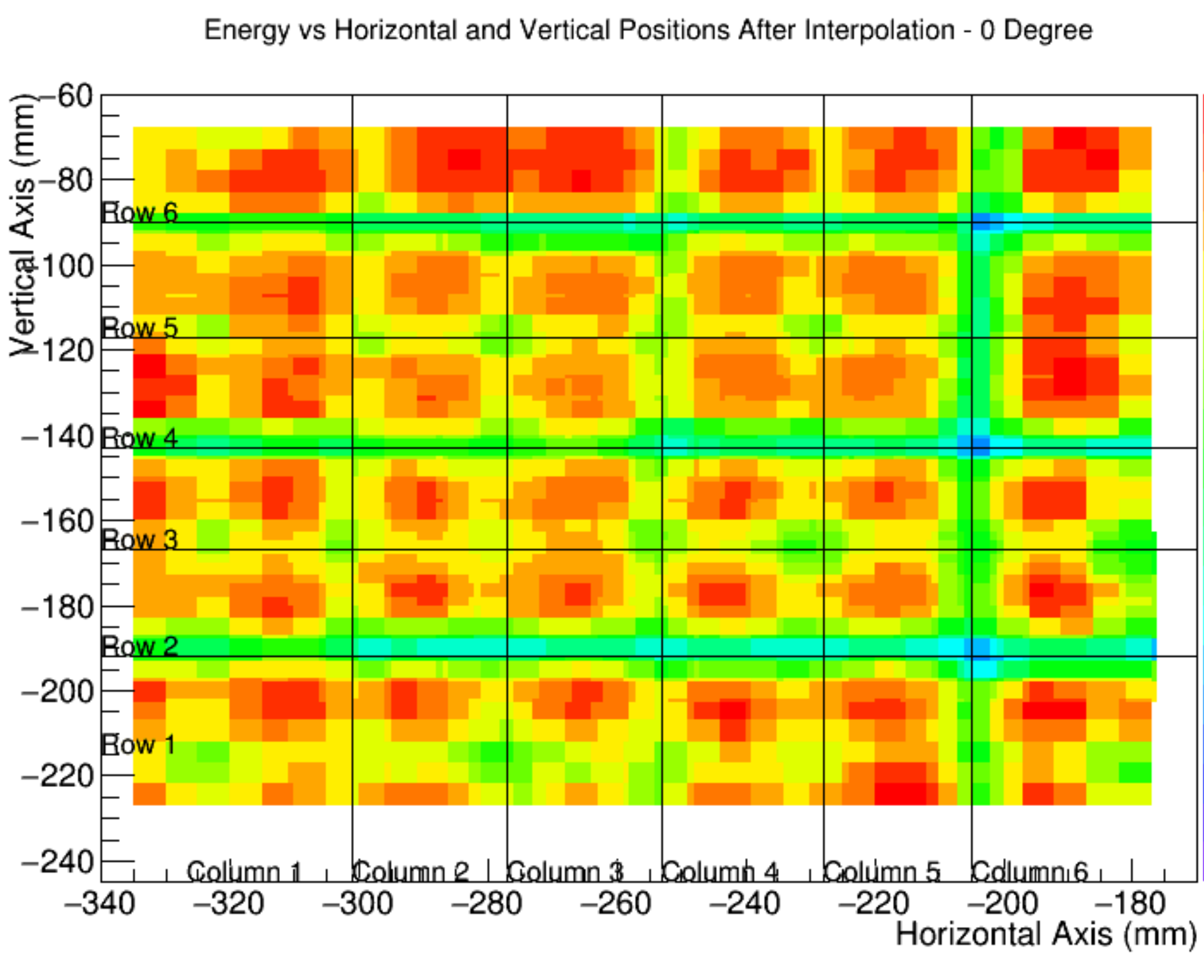
2017 prototype

- 2D projectivity, close to the final design
- blocks are 2x2 towers ➝ ~twice as large as in 2016 prototype
- longest step is filling the fibers into meshes
  - holes don't line up because of the projectivity so we developed a 3D printed spacer setup to funnel the fibers through; supported with a solo cup
  - 3D printed molds to cast the blocks

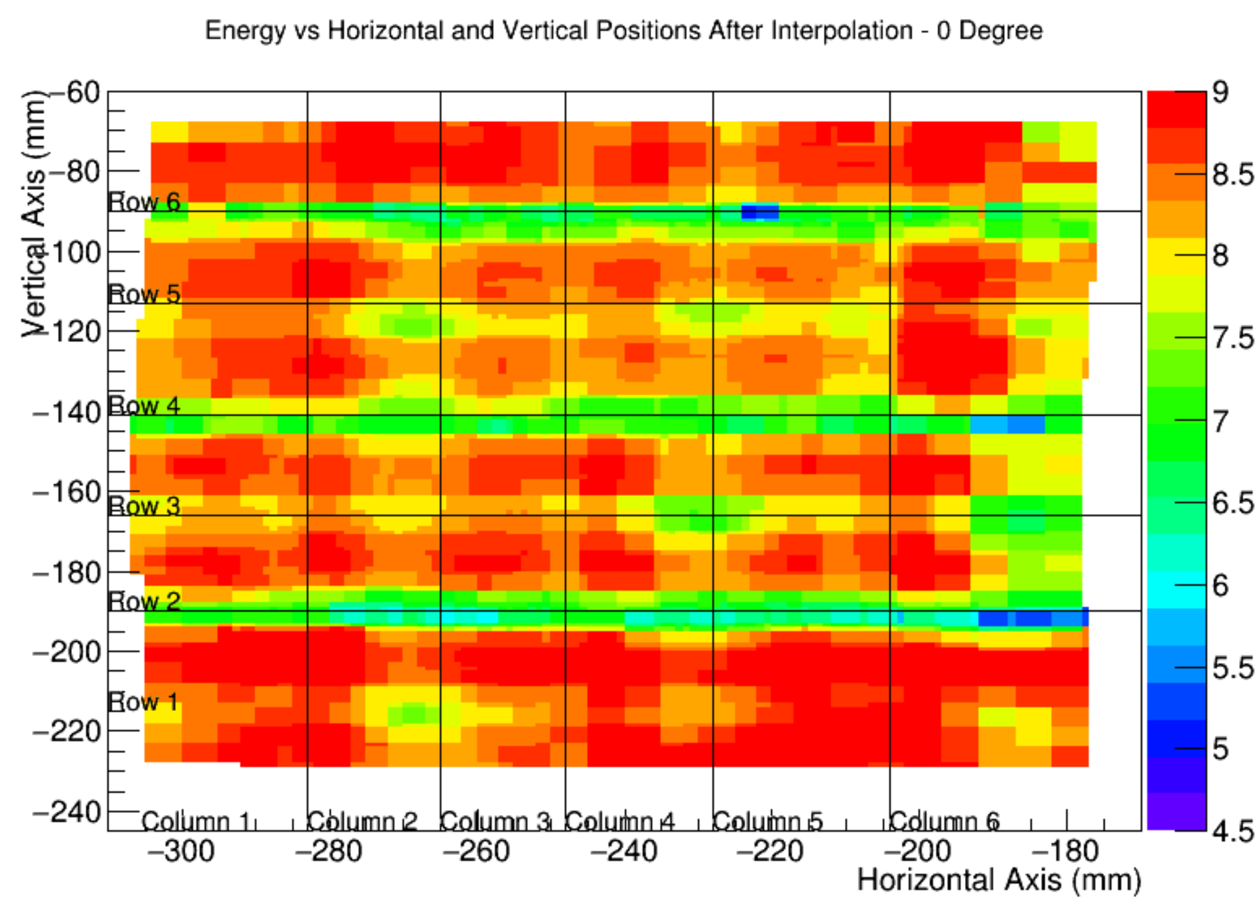
boundary effects

- one goal of the 2017 prototype was to figure out if the dominate position dependence was the block boundaries or the the tower boundaries
  - full scan of the calorimeter face with 8 GeV electrons

normally incident beam



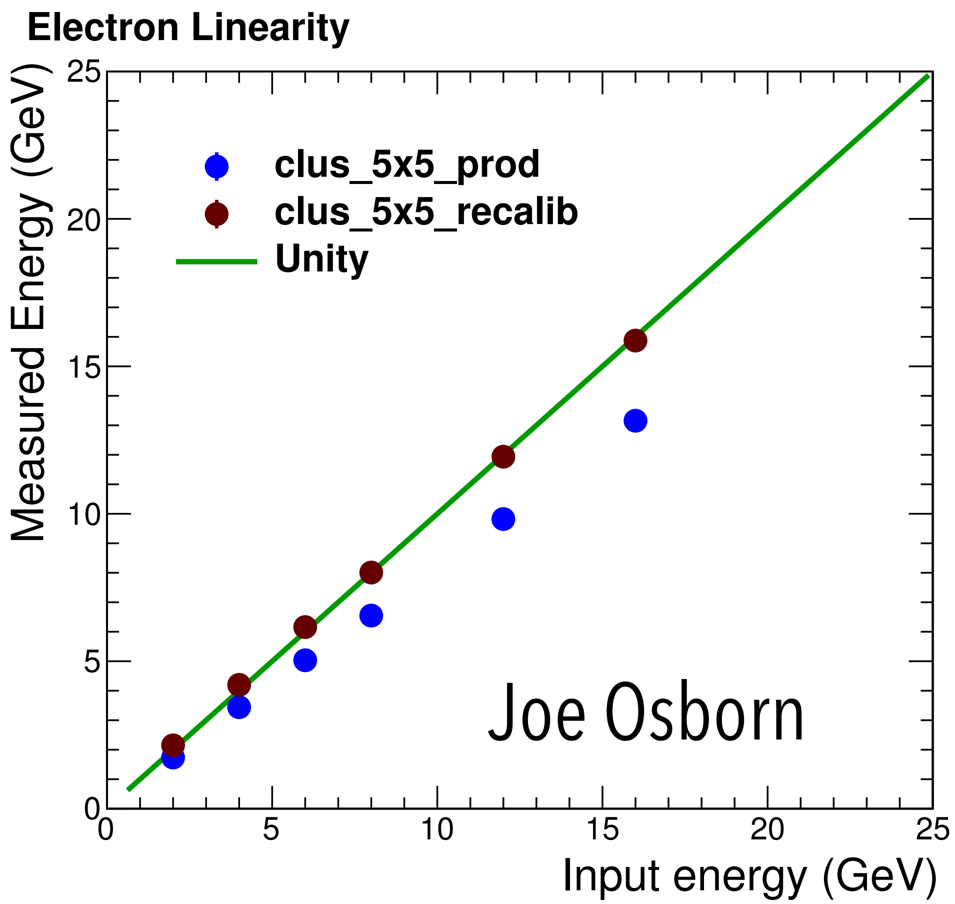
10 deg rotation

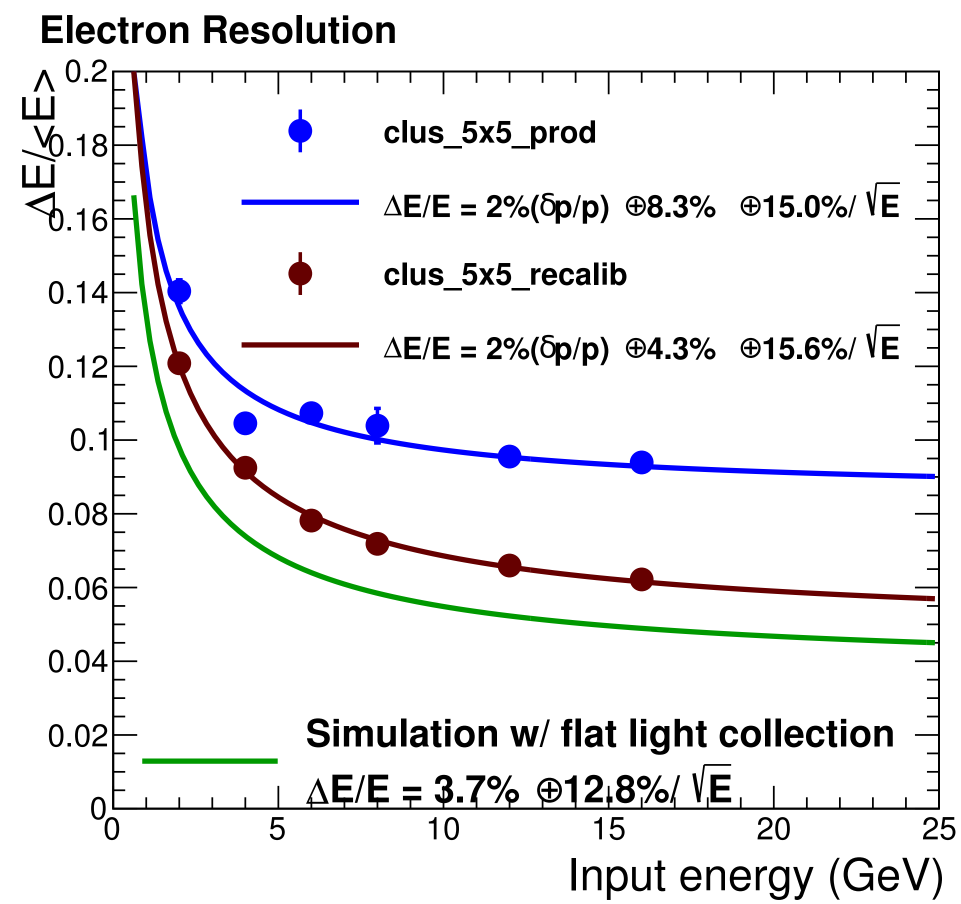


Zhaozhong Shi (MIT)

clear effect of block & tower boundaries, block boundaries larger effect

energy resolution





including all response variations

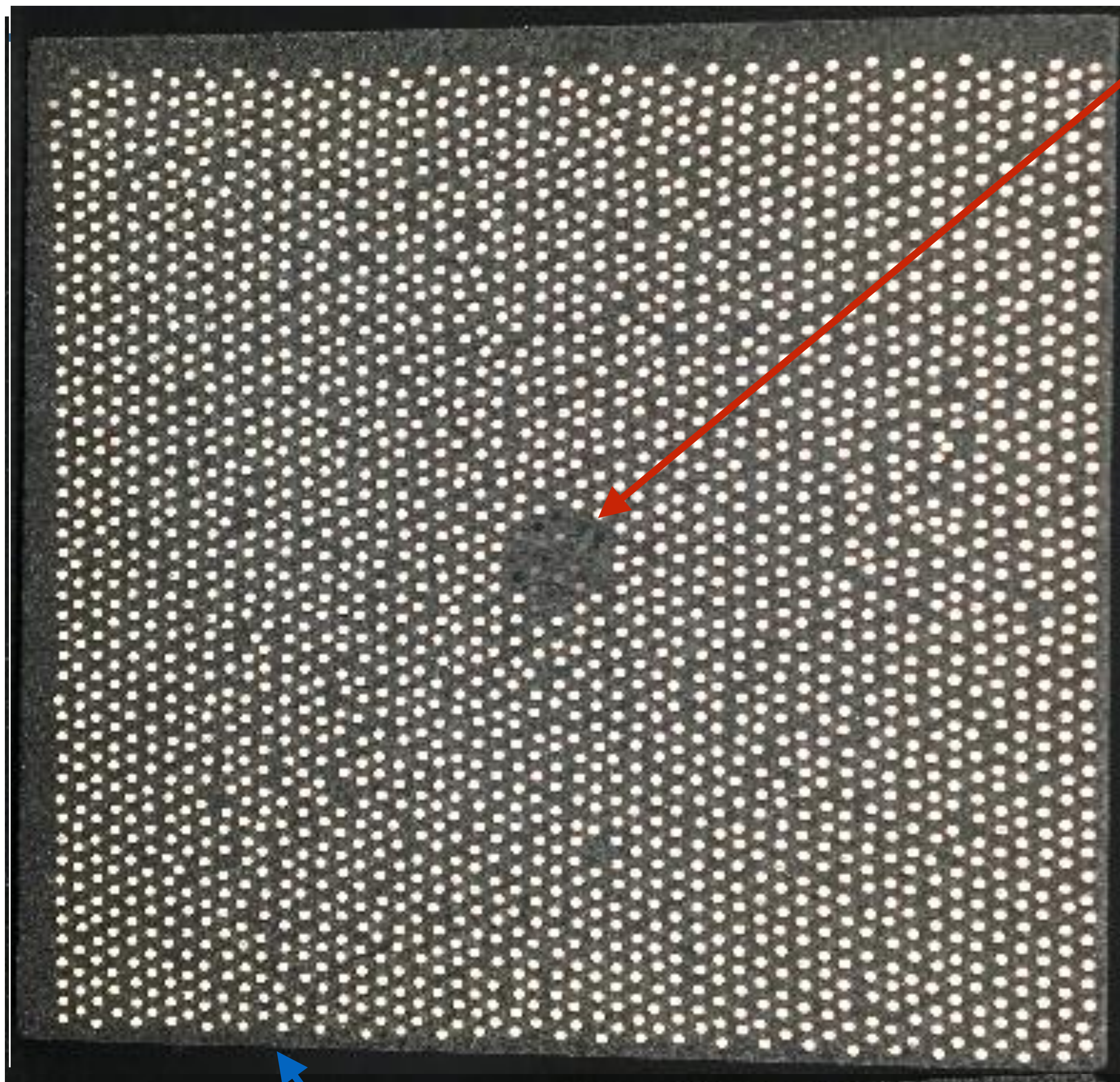
position dependence correction

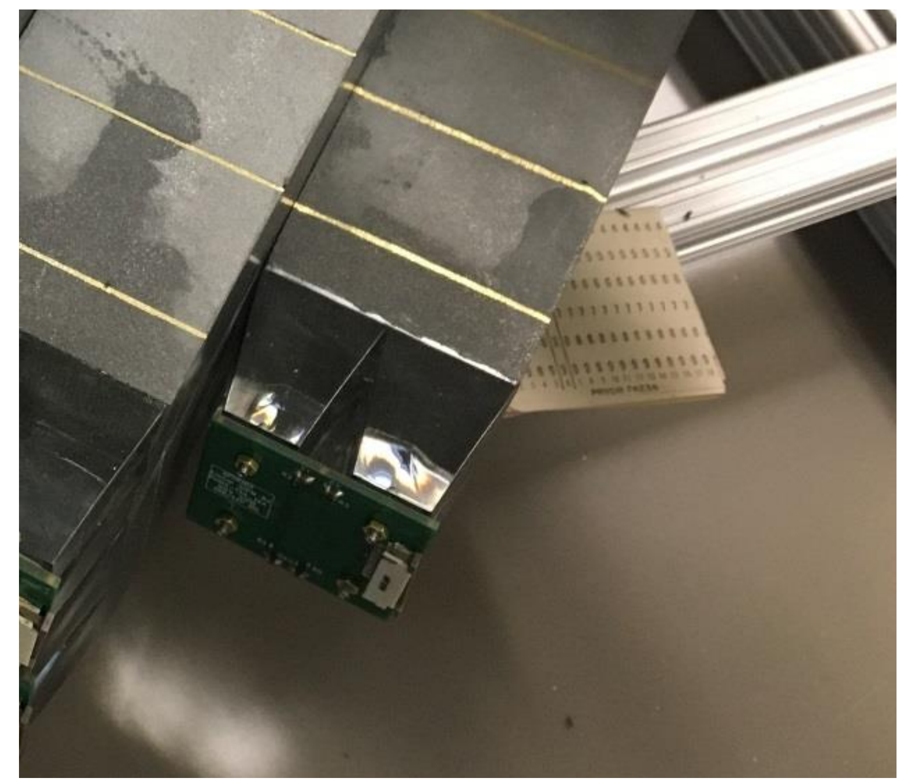
dramatic reduction in constant term with the position dependent correction

causes of position dependence

1 block; 4 towers

shadow of drilled support hole in the back of blocks



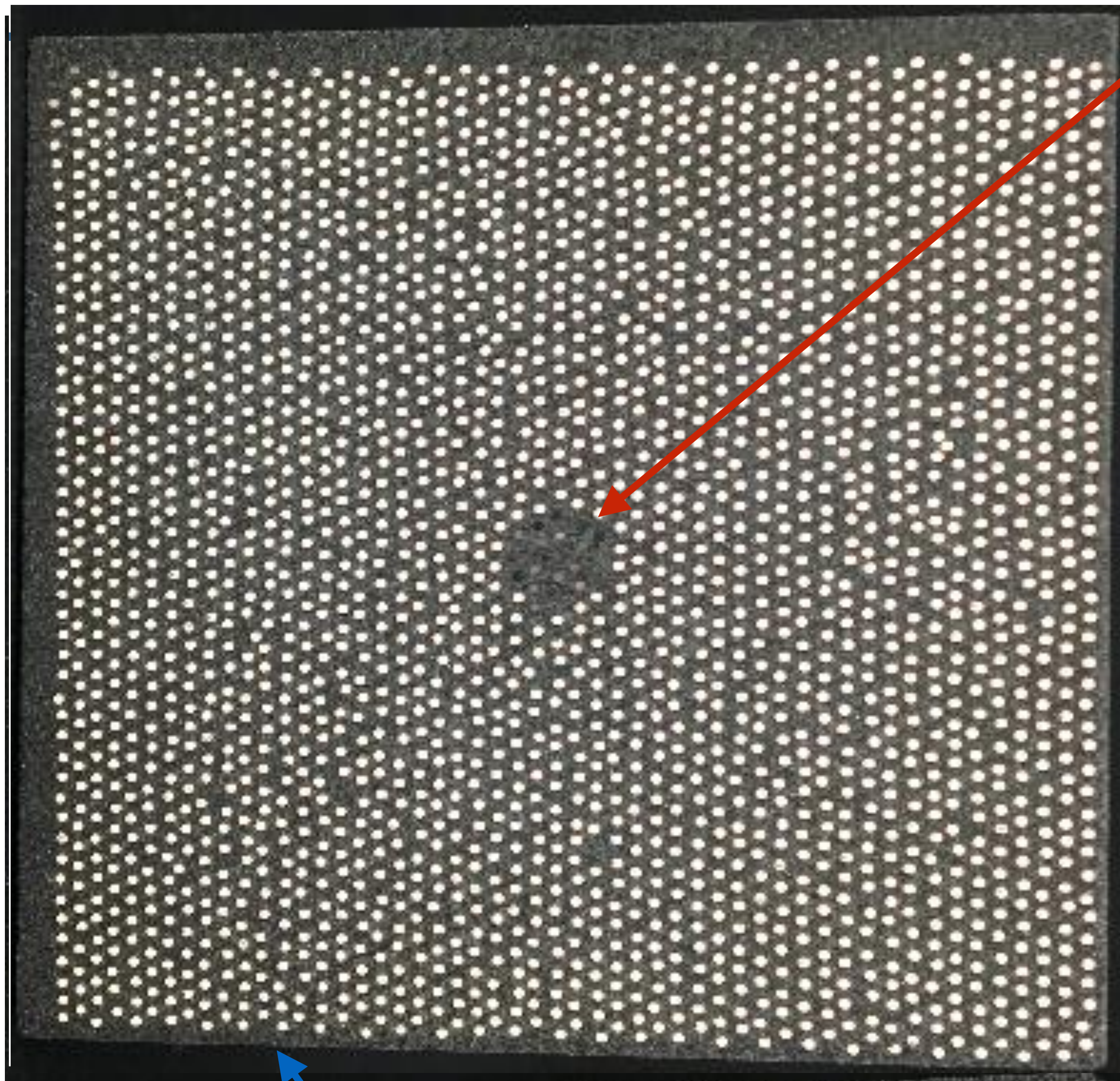


reduced light collection near the edge of lightguides

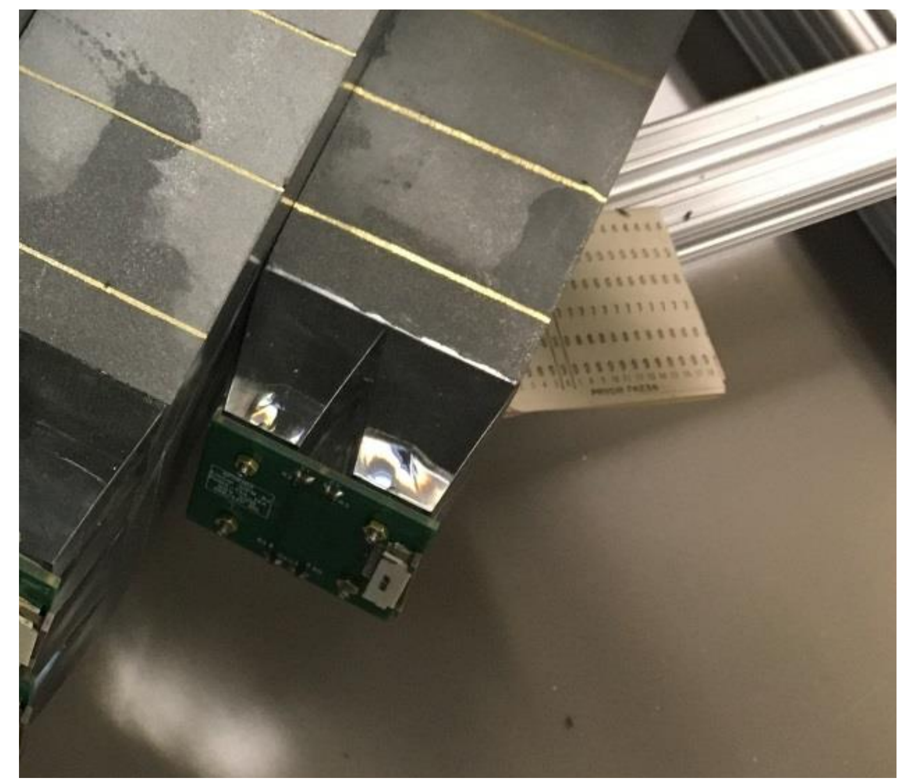
dead tungsten border around blocks

improvements to position dependence

1 block; 4 towers



support the blocks in a less invasive manner (investigating epoxy)



bring the fibers in from the edges at the block (and tower?) boundaries

focus on QA of blocks and tolerances, slight non-projectivity

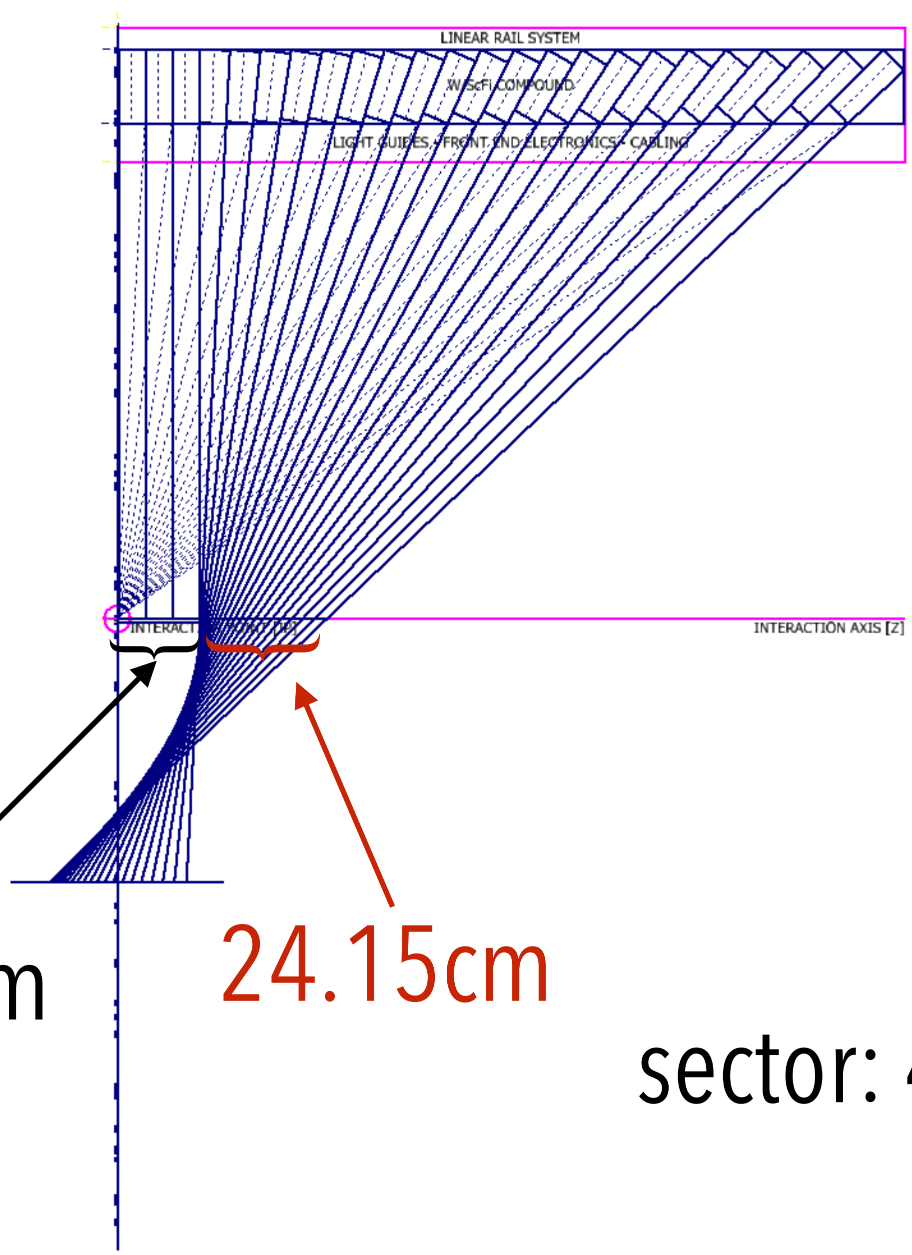
mold improvements for 2018 prototype

- moved from 3D printed to machined delrin molds
    - machining provides better adherence to block dimensions and repeatability
    - better screen positioning within the block
    - both of these allow fibers to be closer to the edge of the blocks
    - only the top of the block and ends are machined (“bathtub” mold) the other sides are defined by the mold
- this was philosophy behind the 2016 prototype construction where the fiber positioning was better than in 2017

non-projectivity

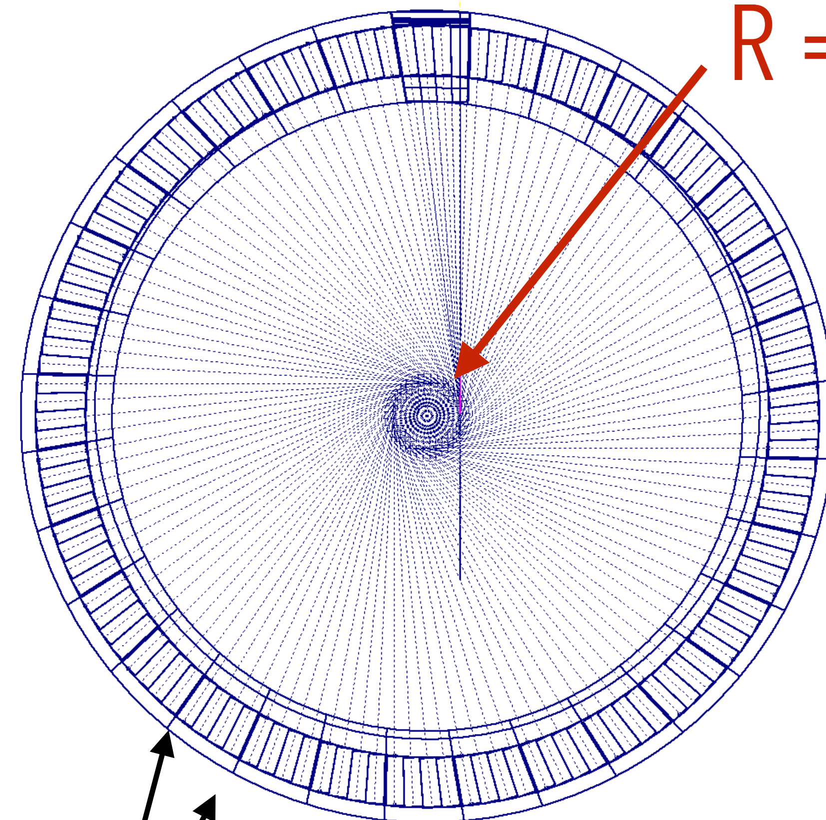
total width is 48 blocks in η, six blocks around $\eta = 0$ have the same shape → 22 different block shapes

slight non-projectivity: 100mrad in azimuth and 150mrad in η



15.5cm

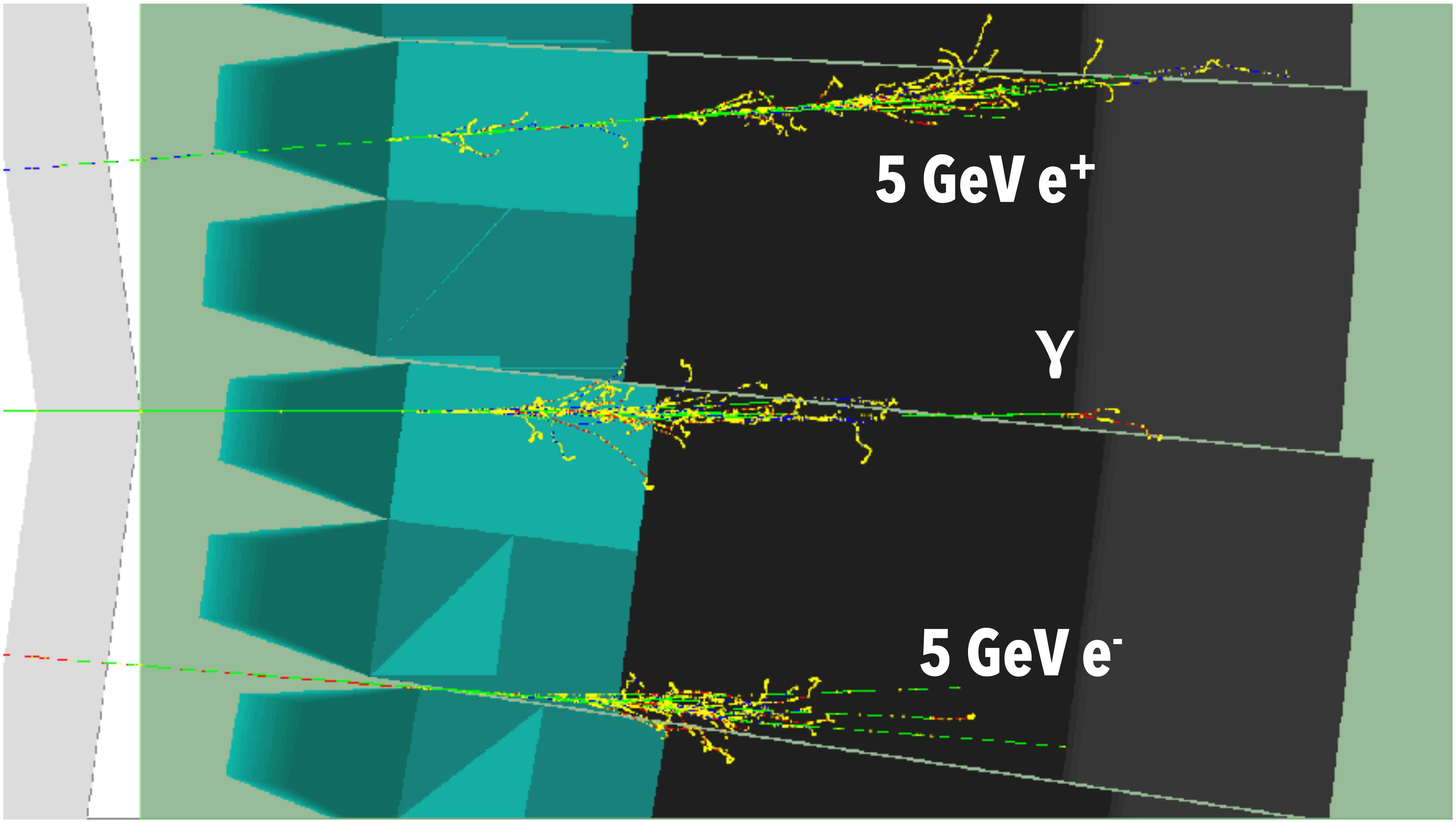
24.15cm



R =10cm

sector: 4 blocks wide in ϕ, 32 sectors around

tilted blocks

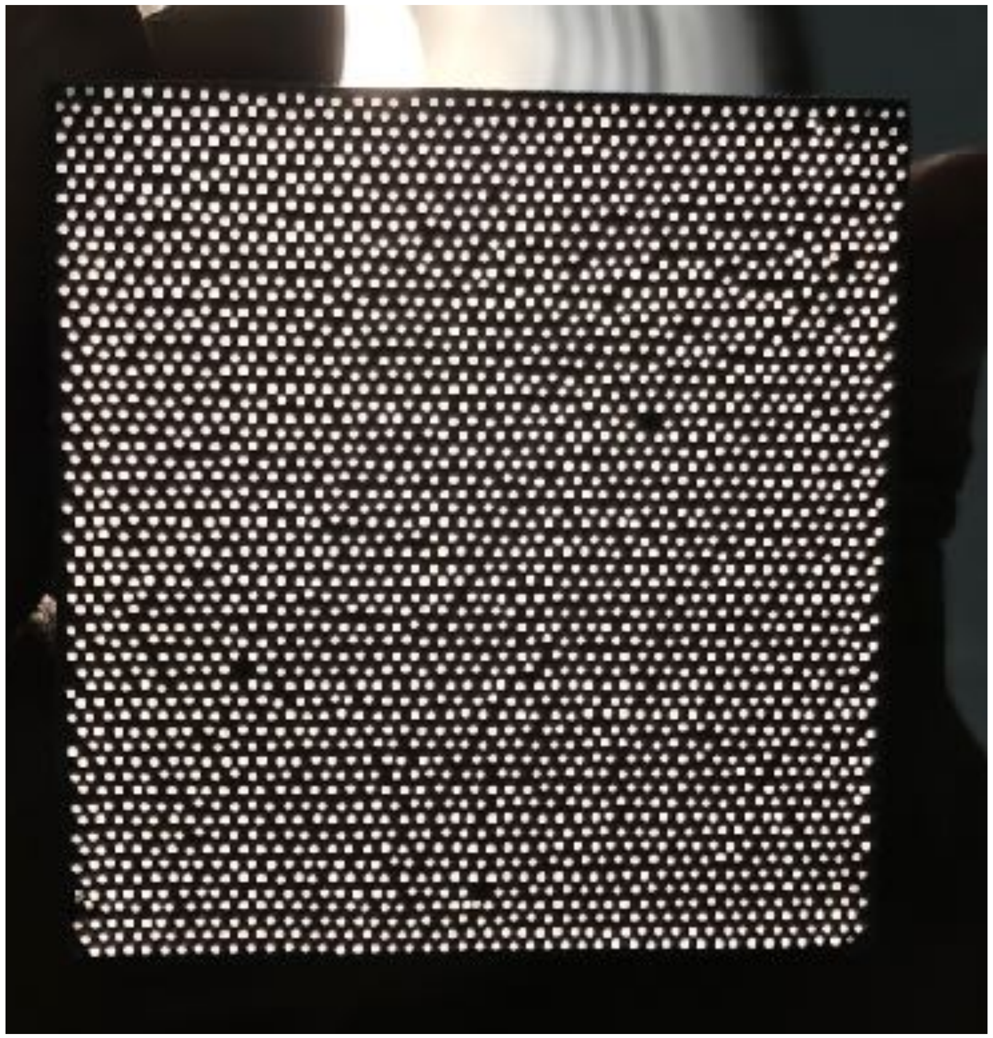


no channeling for photons or electrons

unifying the light collection

first test block of the 2018 prototype design

back



fibers very close to edge
(being quantified)

front (readout side)

fibers brought in from edges with
a small taper

(download the slides to see the pictures better)

unifying the light collection

first test block of the 2018 prototype design

front (readout side)

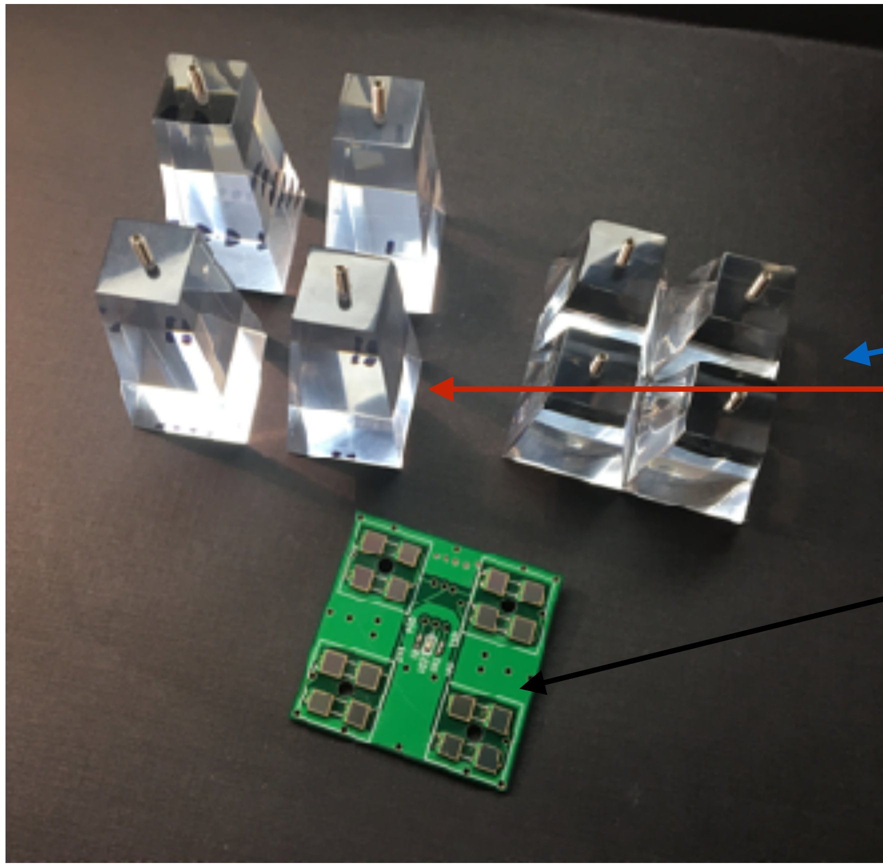
common footprint for the lightguide also allows a common shape for all 22 block shapes significant savings on molds and complexity

fibers brought in from edges with a small taper

investigating whether a tower boundary taper can be added

(download the slides to see the pictures better)

light guides & readout



2017 prototype used 2 types of lightguides:

quad injection molded 1″ tall

2″ tall single machined

both read out with 4 SiPMs / tower

machined lightguides are too expensive & the injection molded had a large quality variation & high rejection rate

neither solution seen as reasonable

simulations over the summer suggest that the trapezoid shape is optimal for our readout

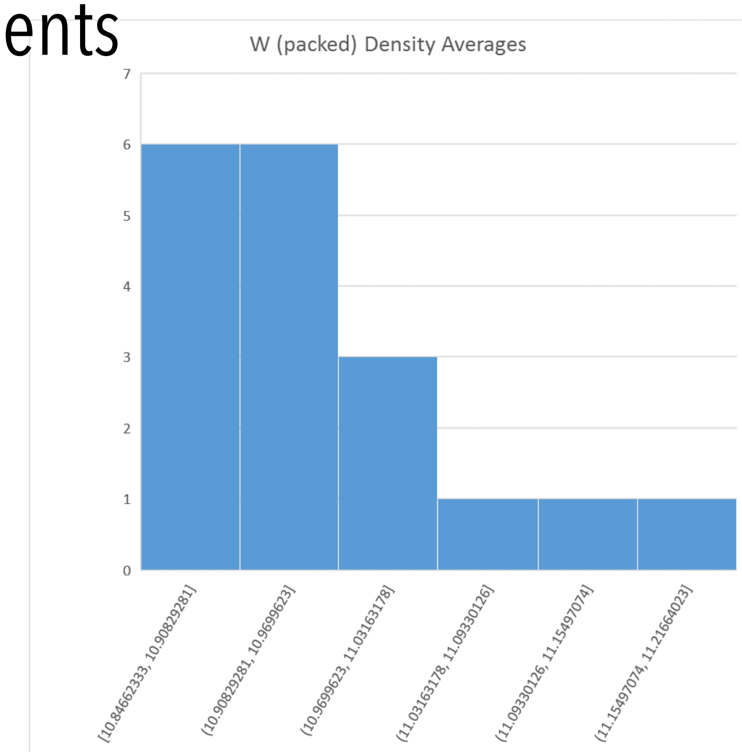
2018 lightguides

- optical injection molded single light guides
- tapered fibers allow a single lightguide shape to be used for all lightguides
  - good since the cost for the mold is ~$17k
  - company: Precision Engineered Products
  - going to order these very soon.

2018 prototype construction

- dry run of mass production techniques for the final detector
- undergrad fiber filling and QA development ongoing
- developing powder QA at Illinois
  - bucket by bucket (50-100 lb quantities) density measurements
    - mean 10.96 g/cm3, std deviation 1.2%
- fibers:
  - 2016 & 2017 prototypes used Kurrary fibers
  - 2018 prototype switched to Saint Gobain
    - better price, nominally the same product, to be delivered to Illinois this week

powder density by bucket



production facility at Illinois

clearing extra space for the larger scale production

tungsten

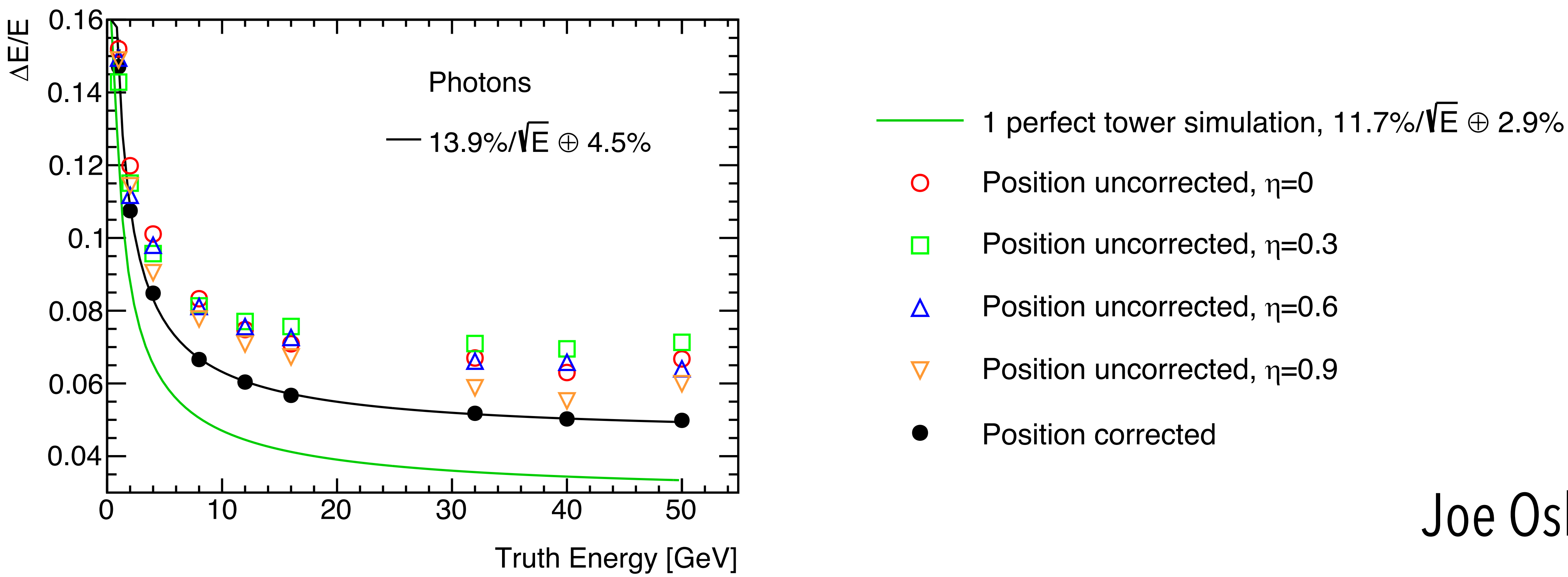
enough powder on hand for 2018 prototype, with additional order in process have enough for full sector prototype as well

timeline

- summer: build blocks for 2018 (v2.1) prototype
  - materials in had except for the fiber expected this week
  - ship to BNL for assembly for February/March 2018 beam test
- late summer & fall:
  - fill fiber assemblies for full sector prototype
  - fall and winter: cast blocks for full sector prototype
    - this will not be tested in beam
  - firm up production schedule:
    - EMCal block production is the critical path for sPHENIX
    - demonstrate that the tolerances can be consistently met and arrange blocks into the sector casing (BNL, winter)

simulations

- populating the entire detector with a design consistent with the 2018 prototype: Jin Huang
- clusters reconstructed with the sPHENIX clustering software
  - this clustering just adds adjacent energy
- single photon simulations
- use measured position dependent light collection efficiency
  - correct for it using the same techniques as in the prototype
- much progress on the last few weeks



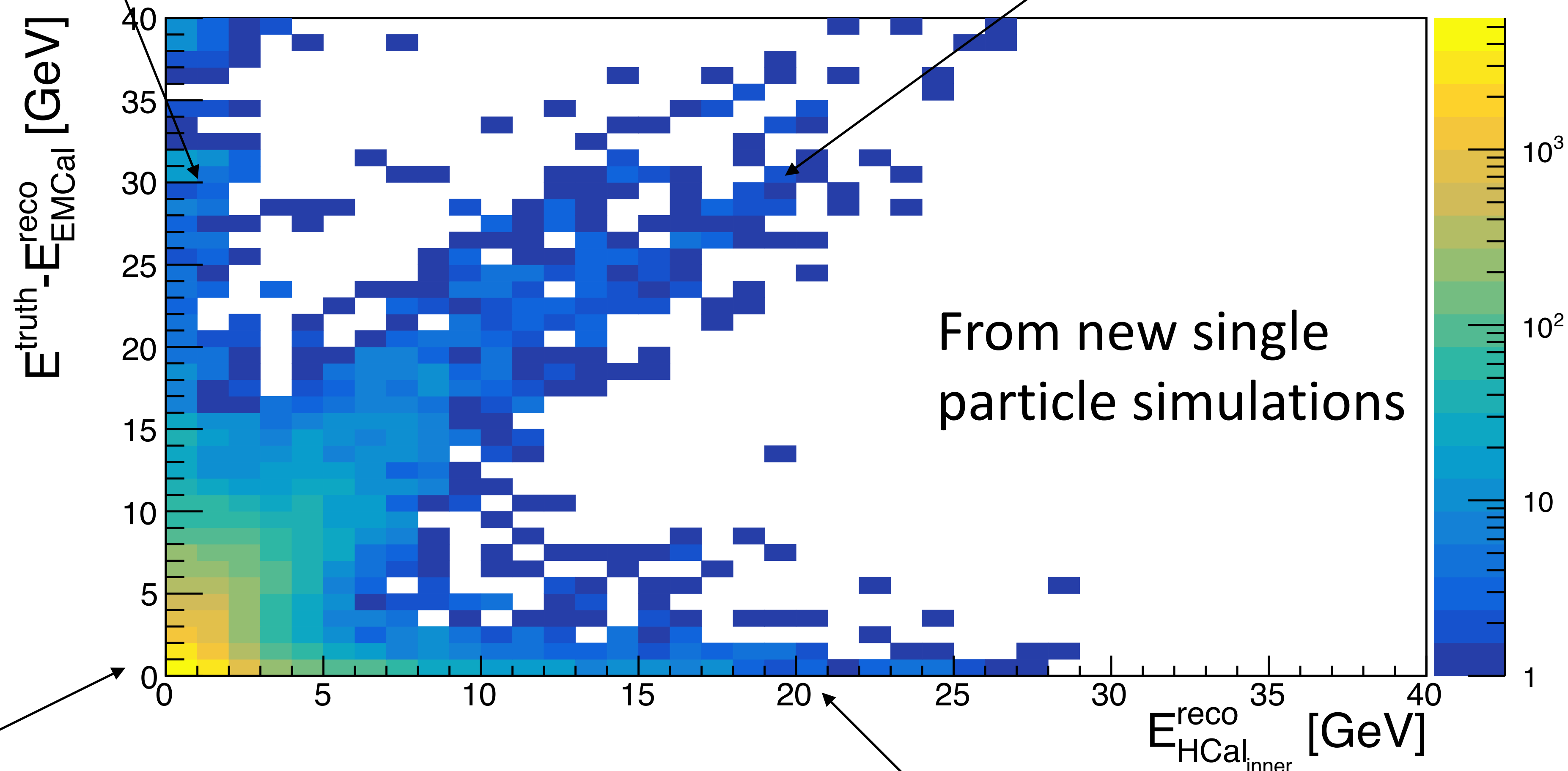
Joe Osborn

energy responses: EMCal & Inner HCal

first look at single photon simulations

clusters with lower than expected energy,
some of this from 1 photon → >1 cluster

energy leaks from EMCal into inner HCal



bulk of the clusters
$E_{EMCal} \sim E_{truth}$

expected EMCal energy + extra inner HCal energy
under investigation

Joe Osborn

summary

- good performance of 2016 & 2017 prototypes
- 2017 prototype was the first 2D projective tungsten powder Spacal
- 2018 has targeted improvements in design and emphasis on QA and consistency in the production process
    - leads into full sector (96 block) prototype for construction in FY18
- good progress on the simulation in a very short time
    - single particle results are ~as expected
    - more manpower needed
    - HI simulations are in progress but would be helped by more manpower